Claims

Claims 1-72 (canceled)

73. (previously presented) A method for reducing adsorbent degradation by moisture adsorption while producing a product gas in a pressure swing adsorption process, comprising:

providing a fast cycle PSA apparatus comprising adsorbers with contaminant-sensitive adsorbents having a feed end fluidly coupled to a breather through an isolation valve, the adsorbers comprising a guard material to adsorb a contaminant in a guard layer zone and a second material in an adsorbent zone to produce a product fluid by a pressure swing, the guard layer zone being isolated on shutdown from the adsorbent zone by an isolation valve in a fluid path between the guard layer zone and the adsorbent zone;

introducing a feed gas to the feed end; and

using the PSA apparatus to produce a product gas by a pressure swing adsorption process over the adsorbers after removal of contaminant from the feed gas.

74. (original) The method according to claim 73 where the contaminant is water.

Claim 75 (canceled)

76. (previously presented) The method according to claim 73 where the PSA apparatus is a rotary apparatus operating at a cycle frequency of at least 30 cycles per minute.

Claims 77-78 (canceled)

79. (original) The method according to claim 73 further comprising introducing to a product delivery compartment a product gas produced by pressure swing adsorption over the adsorbers.

Claims 80-81 (canceled)

82. (original) A method for reducing adsorbent degradation while producing a product gas in a pressure swing adsorption process, comprising:

providing a PSA apparatus comprising a breather fluidly coupled to a feed plenum, a rotor for housing adsorbers and rotating the adsorbers to receive feed fluid from the plenum at normal process rotary speeds at least as high as 30 cycles per minute, plural adsorbers housed in the rotor and having a first end which receives feed fluid from the feed plenum and a second end positioned to deliver product gas produced by a pressure swing adsorption process to a product delivery compartment, the adsorbers comprising at least a first desiccant zone and a second adsorbent zone, seals for sealing a buffer chamber about the light product delivery compartment, the buffer chamber receiving a gas having a water vapor content the same as or less than the product gas, and a product delivery conduit for delivering a desired product gas; and

using the PSA apparatus.

83. (original) A method for shutting down a PSA apparatus according to a shutdown sequence, comprising:

operating a rotary PSA apparatus having a feed end fluidly coupled to a first end of adsorbers that include a first material for adsorbing a contaminant and at least one contaminant-sensitive adsorbent for producing a product fluid by pressure swing adsorption, the PSA apparatus further including a product end coupled to a second end of the adsorbers for delivering a product fluid;

discontinuing product fluid delivery;

exhausting feed gas;

introducing a blanket gas into a feed end of the PSA apparatus;

discontinuing delivery of fluid feed mixture to the feed end; and

purging the adsorbers with a purge fluid.

84. (original) The method according to claim 83 and further comprising preparing the apparatus for elevated pressure parking, the method comprising closing an exhaust port and introducing a blanket gas into the feed end to pressurize the apparatus to a pressure above ambient.

85. (original) The method according to claim 84 where the apparatus is pressurized to a park pressure of at least 0.5 bar above ambient.

86. (original) The method according to claim 83 further comprising discontinuing rotor rotation and engaging any parking seal.

87. (original) The method according to claim 83 and further comprising heating the first material to facilitate desorption of adsorbed contaminant.

88. (original) The method according to claim 83 where the contaminant is water.

89. (original) The method according to claim 87 and further comprising cooling the desiccant after purge.

Claim 90 (canceled)

91. (original) The method according to claim 83 where the contaminant is water and the adsorbers are purged using a purge gas having a water vapor content substantially equal to water vapor content of the product gas produced by a PSA process over the adsorbers

Claims 92-97 (canceled)

98. (previously presented) A method for increasing operation time before shutdown is required of a rotary fast cycle PSA apparatus, comprising:

providing a PSA unit having a feed air dryer upstream of a feed end of the PSA unit, and adsorbers having a desiccant layer at the feed end of the adsorbers, the adsorbers comprising high surface area laminated adsorbers, with the adsorbent supported in thin adsorbent sheets separated by spacers to define flow channels between adjacent sheets; and

operating the PSA unit under normal operating conditions useful for producing a product fluid.

Claim 99 (canceled)

100. (previously presented) The method according to claim 98 where the laminated adsorbers include a desiccant layer for adsorbing water at the feed end of the sheets.

101. (previously presented) The method according to claim 98 where the desiccant is selected from the group consisting of alumina, aluminosilicate gels, silica gels, zeolites, activated carbon, carbon molecular sieves and combinations of these materials.

102. (original) The method according to claim 98 and further comprising providing a buffer space between the internal working zone of valves communicating to the product ends of the adsorbers, the buffer space being a positive pressured dry fluid flushed zone.

103. (original) The method according to claim 102 where the buffer chamber has flushing circulation provided by delivered product flow.

104. (original) The method according to claim 98 comprising placing a contaminant trap in at least one light reflux line of the PSA apparatus.

105. (original) The method according to claim 104 where the contaminant trap adsorbs water.

106. (original) The method according to claim 104 where activity of the contaminant trap is maintained by periodic regeneration or replacement.

107. (original) The method according to claim 98 and further comprising placing a desiccant trap in the product line.

108. (previously presented) The method according to claim 98 where a target water vapor pressure at the product end is substantially that of the selected adsorbent material at the product end.

109. (original) The method according to claim 108 where the water vapor pressure ranges from about 0.005 Pa to about 0.01 Pa at 30°C.

110. (original) A method for producing a positive pressure park mode in a fast cycle rotary PSA apparatus, comprising:

shutting down a rotating PSA system to reduce desiccant water loading;

introducing a fluid into a feed end of the apparatus to provide a park pressure above ambient;

closing all ports and discontinuing rotor rotation; and

engaging a parking seal.

Claims 111-121 (canceled)

122. (previously presented) A method for shutting down a PSA apparatus according to a shutdown sequence, comprising:

operating a fast cycle PSA apparatus having a feed end fluidly coupled to ~~a~~ first ends of adsorbers that include a guard layer and at least one contaminant-sensitive adsorbent, the PSA apparatus further including a product end coupled to ~~a~~ second ends of the adsorbers for delivering a product fluid;

introducing a feed fluid to the first ends and substantially removing a contaminant fluid from the feed fluid to produce a containment-free fluid prior to the contaminant-free fluid contacting the contaminant-sensitive adsorbents;

performing a pressure swing using the fast cycle PSA apparatus to separate a product fluid by a pressure swing adsorption process over the adsorbers by contacting the contaminant-sensitive adsorbents with the contaminant-free fluid;

stopping delivery of product fluid;

purging adsorbers with product flow; and

heating the guard layer.

123. (original) The method according to claim 122 and further comprising cooling the adsorbers.

124. (original) The method according to claim 122 where heating the guard layer comprises directly heating the guard layer using heating means.

125. (previously presented) The method according to claim 124 where the heating means is selected from the group consisting of resistance heating, microwave heating, infra red heating, seal friction, reducing cooling load, and combinations thereof.

126. (original) The method according to claim 122 where the guard layer is heated by fluid flow.

127. (previously presented) The method according to claim 122 where the guard layer is heated by a heating process selected from the group consisting of compressor work, resistance heating, adsorption heating of upstream guard trap, using a heat exchanger, and combinations thereof.

Claims 128-158 (canceled)

159. (previously presented) A method for reducing degradation of a contaminant-sensitive adsorbent material due to adsorption of at least one contaminant, where the adsorbent material is used to produce at least one product fluid enriched in a first component relative to a second component from a feed fluid using an adsorption process, the feed fluid containing at least the first and second components, comprising:

providing an adsorption apparatus comprising at least one adsorber having a feed end and a product end, and including at least one contaminant-sensitive adsorbent material used to produce the at least one product fluid, the adsorber including a layer of guard material for controlling flow of at least a portion of the at least one contaminant to the at least one contaminant–sensitive adsorbent material;

providing a flow of feed fluid comprising the at least one contaminant to the at least one adsorber, the feed fluid contacting the at least one contaminant-sensitive adsorbent material;

controlling flow of the at least one contaminant to the at least one adsorbent material and further comprising reducing diffusion of the at least one contaminant from the guard material to the at least one contaminant-sensitive adsorbent material; and

enriching the first component relative to the second component to produce the at least one product fluid.

160. (previously presented) The method according to claim 159 where the adsorption process is a pressure swing adsorption process, and the adsorption apparatus is a pressure swing adsorption apparatus.

161. (previously presented) The method according to claim 159 where the adsorption process is a non-conventional pressure swing adsorption process, and the adsorption apparatus is a non-conventional pressure swing adsorption apparatus.

162. (previously presented) The method according to claim 161 where the adsorption apparatus comprises a stator and a rotor relatively rotatable with respect to the stator, the stator and rotor mutually defining a rotary valve surface and where the adsorption process has a process cycle frequency of at least 10 cycles per minute.

163. (previously presented) The method according to claim 159 where the at least one contaminant comprises water.

164. (previously presented) The method according to claim 160 where the at least one contaminant comprises water.

165. (previously presented) The method according to claim 161 where the at least one contaminant comprises water.

166. (previously presented) The method according to claim 162 where the at least one contaminant comprises water.

Claims 167-171 (canceled)

172. (previously presented) The method according to claim 159 where the feed fluid comprises a water contaminant and the at least one adsorber includes a layer of guard material positioned between the feed end of the at least one adsorber and at least one water-sensitive adsorbent material, the guard material controlling the flow of at least a portion of the water contaminant to the at least one water-sensitive adsorbent material, the adsorption process is a pressure swing adsorption process, and the adsorption apparatus is a pressure swing adsorption apparatus.

173. (currently amended) The method according to claim 159 where the feed fluid comprises a water contaminant and the at least one adsorber includes a layer of guard material positioned between the feed end of the at least one adsorber and at least one water-sensitive adsorbent material, the guard material controlling the flow of at least a portion of the water contaminant to the at least one water-sensitive adsorbent material, the adsorption process is a non-conventional pressure swing adsorption process, and the adsorption apparatus is a non-conventional pressure swing adsorption ~~process~~ apparatus.

174. (previously presented) The method according to claim 159 further comprising reducing concentration of the at least one contaminant in the guard material from a normal operational condition concentration to a lower parked condition concentration.

Claims 175-177 (canceled)

178. (previously presented) The method according to claim 159 further comprising fluidly isolating the guard material from the at least one contaminant-sensitive adsorbent material during a parked condition.

Claims 179-183 (canceled)

184. (previously presented) The method according to claim 159 where the adsorption apparatus comprises a stator and a rotor relatively rotatable with respect to the stator, the stator and rotor mutually defining a rotary valve surface and where the adsorption process has a process cycle frequency of at least 10 cycles per minute.

Claims 185-187 (canceled)

188. (previously presented) The method according to claim 159 comprising reducing overloading of the guard material with the at least one contaminant component during start-up.

Claim 189 (canceled)

190. (previously presented) The method according to claim 188 where the adsorption apparatus comprises a stator and a rotor relatively rotatable with respect to the stator, the stator and rotor mutually defining a rotary valve surface and where the adsorption process has a process cycle frequency of at least 10 cycles per minute.

191. (previously presented) The method according to claim 190 where the contaminant comprises water.

192. (previously presented) The method according to claim 174 comprising reducing overloading of the guard material with the at least one contaminant component during start-up.

193. (previously presented) The method according to claim 178 comprising reducing overloading of the guard material with the at least one contaminant component during start-up.

194. (previously presented) The method according to claim 159 where the adsorption apparatus further comprises at least one process containment seal fluidly connected to the at least one adsorber, and located proximal to the product end of the at least one adsorber.

195. (previously presented) The method according to claim 160 where the adsorption apparatus further comprises at least one process containment seal fluidly connected to the at least one adsorber, and located proximal to the product end of the at least one adsorber.

196. (previously presented) The method according to claim 161 where the adsorption apparatus further comprises at least one process containment seal fluidly connected to the at least one adsorber, and located proximal to the product end of the at least one adsorber.

197. (previously presented) The method according to claim 196 where the adsorption apparatus comprises a stator and a rotor relatively rotatable with respect to the stator, the stator and rotor mutually defining a rotary valve surface and where the adsorption process has a process cycle frequency of at least 10 cycles per minute.

198. (previously presented) The method according to claim 196 where the contaminant comprises water.

199. (previously presented) The method according to claim 196 where the feed fluid comprises the contaminant and the at least one adsorber includes a layer of guard material positioned between the feed end of the at least one adsorber and the at least one contaminant-sensitive adsorbent material, the guard material controlling flow of at least a portion of the at least one contaminant to the at least one contaminant-sensitive adsorbent material.

200. (previously presented) The method according to claim 199 further comprising reducing concentration of the at least one contaminant in the guard material from a normal operational condition concentration to a parked condition concentration.

201. (previously presented) The method according to claim 199 further comprising fluidly isolating the guard material from the at least one contaminant-sensitive adsorbent material during a parked condition.

202. (previously presented) The method according to claim 199 further comprising reducing diffusion of the at least one contaminant from the guard material to the at least one contaminant-sensitive adsorbent material.

203. (previously presented) The method according to claim 194 where the at least one process containment seal allows at least a portion of contained process fluid to flow across the seal.

204. (previously presented) The method according to claim 195 where the at least one process containment seal allows at least a portion of contained process fluid to flow across the seal.

205. (previously presented) The method according to claim 196 where the at least one process containment seal allows at least a portion of contained process fluid to flow across the seal.

206. (previously presented) The method according to claim 203 where the portion of contained process fluid flowing across the seal also flows through a contaminant guard trap located downstream of the seal.

207. (previously presented) The method according to claim 204 where the portion of contained process fluid flowing across the seal also flows through a contaminant guard trap located downstream of the seal.

208. (previously presented) The method according to claim 205 where the portion of contained process fluid flowing across the seal also flows through a contaminant guard trap located downstream of the seal.

209. (previously presented) The method according to claim 194 where the adsorption apparatus further comprises at least one primary seal or a static seal, defining a buffer space.

210. (previously presented) The method according to claim 195 where the adsorption apparatus further comprises at least one primary seal or a static seal, defining a buffer space.

211. (previously presented) The method according to claim 196 where the adsorption apparatus further comprises at least one primary seal or a static seal, defining a buffer space.

212. (previously presented) The method according to claim 209 where the adsorption apparatus further comprises at least one buffer seal located inside the buffer space.

213. (previously presented) The method according to claim 210 where the adsorption apparatus further comprises at least one buffer seal located inside the buffer space.

214. (previously presented) The method according to claim 211 where the adsorption apparatus further comprises at least one buffer seal located inside the buffer space.

215. (previously presented) The method according to claim 209 comprising reducing total fluid pressure within the buffer space to at least a lowest pressure of the adsorption process.

216. (previously presented) The method according to claim 212 comprising reducing total fluid pressure within the buffer space to at least a lowest pressure of the adsorption process.

217. (previously presented) The method according to claim 209 where total fluid pressure within the buffer space is reduced below atmospheric pressure.

218. (previously presented) The method according to claim 212 where total fluid pressure within the buffer space is reduced below atmospheric pressure.

219. (previously presented) The method according to claim 209 where the process containment seal has a first side and a second side, the method further comprising introducing a blanket fluid into the buffer space, the blanket fluid having a reduced concentration of the at least one contaminant on the first side of the process containment seal relative to the concentration of

the at least one contaminant in the fluid on the second side of the at least one process containment seal.

220. (previously presented) The method according to claim 212 where the process containment seal has a first side and a second side, the method further comprising introducing a blanket fluid into the buffer space, the blanket fluid having a reduced concentration of the at least one contaminant on the first side relative to the concentration of the at least one contaminant in the fluid on the second side of the at least one process containment seal.

221. (previously presented) The method according to claim 219 where at least a portion of blanket fluid introduced to the buffer space comprises fluid originating from the product end of the at least one adsorber.

222. (previously presented) The method according to claim 220 where at least a portion of blanket fluid introduced to the buffer space comprises fluid originating from the product end of the at least one adsorber.

223. (previously presented) The method according to claim 219 where blanket fluid introduced to the buffer space comprises the product fluid.

224. (previously presented) The method according to claim 220 where blanket fluid introduced to the buffer space comprises the product fluid.

225. (previously presented) The method according to claim 219 where at least a portion of the blanket fluid introduced to the buffer space originates from a source external to the adsorption apparatus.

226. (previously presented) The method according to claim 220 where at least a portion of the blanket fluid introduced to the buffer space originates from a source external to the adsorption apparatus.

227. (previously presented) The method according to claim 225 where the blanket fluid introduced to the buffer space contacts guard material in a guard trap prior to entering the buffer space.

228. (previously presented) The method according to claim 226 where the blanket fluid introduced to the buffer space contacts guard material in a guard trap prior to entering the buffer space.

229. (previously presented) The method according to claim 219 further comprising controlling flow rate of blanket fluid introduced into the buffer space.

230. (previously presented) The method according to claim 220 further comprising controlling flow rate of blanket fluid introduced into the buffer space.

231. (previously presented) The method according to claim 221 further comprising controlling flow rate of blanket fluid introduced into the buffer space.

232. (previously presented) The method according to claim 223 further comprising controlling flow rate of blanket fluid introduced into the buffer space.

233. (previously presented) The method according to claim 225 further comprising controlling flow rate of blanket fluid introduced into the buffer space.

234. (previously presented) The method according to claim 225 where blanket fluid introduced to the buffer space contacts guard material in a guard trap after flowing out of the buffer space.

235. (previously presented) The method according to claim 226 where blanket fluid introduced to the buffer space contacts guard material in a guard trap after flowing out of the buffer space.

236. (previously presented) The method according to claim 219 including controlling a fluid flow path of the blanket fluid introduced into the buffer space.

237. (previously presented) The method according to claim 220 including controlling a fluid flow path of the blanket fluid introduced into the buffer space.

238. (previously presented) The method according to claim 221 including controlling a fluid flow path of the blanket fluid introduced into the buffer space.

239. (previously presented) The method according to claim 223 including controlling a fluid flow path of the blanket fluid introduced into the buffer space.

240. (previously presented) The method according to claim 225 including controlling a fluid flow path of the blanket fluid introduced into the buffer space.

241. (previously presented) The method of claim 219 where total fluid pressure of the blanket fluid introduced to the buffer space is greater than a minimum total pressure of the feed fluid or the product fluid.

242. (previously presented) The method of claim 220 where total fluid pressure of the blanket fluid introduced to the buffer space is greater than a minimum total pressure of the feed fluid or the product fluid.

243. (previously presented) The method according to claim 159 including reducing ingress of the at least one contaminant into the adsorption apparatus during a parked condition relative to a normal operating condition.

244. (previously presented) The method according to claim 194 including reducing ingress of the at least one contaminant into the adsorption apparatus during a parked condition relative to a normal operating condition.

245. (previously presented) The method according to claim 242 including reducing ingress of the at least one contaminant into the adsorption apparatus during a parked condition relative to a normal operating condition.

246. (previously presented) The method according to claim 159, the adsorption apparatus having at least two adsorbers, and wherein the method further comprises normalizing gas compositions between the at least two adsorbers during a parked condition.

247. (previously presented) The method according to claim 194, the adsorption apparatus having at least two adsorbers, and wherein the method further comprises normalizing gas compositions between the at least two adsorbers during a parked condition.

248. (previously presented) The method according to claim 245, the adsorption apparatus having at least two adsorbers, and wherein the method further comprises normalizing gas compositions between the at least two adsorbers during a parked condition.

249. (previously presented) The method according to claim 159, and further comprising reducing ingress during startup of the at least one contaminant into a portion of the at least one adsorber having the at least one contaminant-sensitive adsorbent material.

250. (previously presented) The method according to claim 194, and further comprising reducing ingress during startup of the at least one contaminant into a portion of the at least one adsorber having the at least one contaminant-sensitive adsorbent material.

251. (previously presented) The method according to claim 245, and further comprising reducing ingress during startup of the at least one contaminant into a portion of the at least one adsorber having the at least one contaminant-sensitive adsorbent material.

252. (previously presented) The method according to claim 159, and further comprising reducing contaminant loading of the guard material during startup.

253. (previously presented) The method according to claim 194, and further comprising reducing contaminant loading of the guard material during startup.

254. (previously presented) The method according to claim 243, and further comprising reducing contaminant loading of the guard material during startup.

255. (previously presented) The method according to claim 249, and further comprising reducing contaminant loading of the guard material during startup.

256. (previously presented) The method according to claim 159 additionally comprising regenerating the at least one contaminant-sensitive adsorbent in the at least one adsorber.

257. (previously presented) The method according to claim 159 additionally comprising replacing the at least one contaminant-sensitive adsorbent in the at least one adsorber.

258. (previously presented) A method for reducing degradation of a contaminant-sensitive adsorbent material due to adsorption of at least one contaminant from a source other than the feed fluid, where the adsorbent material is used to produce at least one product fluid enriched in a first component relative to a second component from a feed fluid using an adsorption process, the feed fluid containing at least the first and second components, comprising:

providing an adsorption apparatus comprising at least one adsorber having a feed end and a product end, and including at least one contaminant-sensitive adsorbent material used to produce the at least one product fluid, the adsorption apparatus further comprising at least one process containment seal fluidly connected to the at least one adsorber;

providing a flow of feed fluid to the at least one adsorber, the feed fluid contacting the at least one contaminant-sensitive adsorbent material;

controlling flow of the at least one contaminant to the at least one adsorbent material; and

enriching the first component relative to the second component to produce the at least one product fluid.

259. (previously presented) The method according to claim 258 where the at least one process containment seal allows at least a portion of contained process fluid to flow across the seal.

260. (previously presented) The method according to claim 258 where the adsorption apparatus further comprises at least one primary seal or a static seal, defining a buffer space.

261. (previously presented) The method according to claim 258 including reducing ingress of the at least one contaminant into the adsorption apparatus during a parked condition relative to a normal operating condition.

262. (previously presented) The method according to claim 258, the adsorption apparatus having at least two adsorbers, and wherein the method further comprises normalizing gas compositions between the at least two adsorbers during a parked condition.

263. (previously presented) The method according to claim 258 and further comprising reducing ingress during startup of the at least one contaminant into a portion of the at least one adsorber having the at least one contaminant-sensitive adsorbent material.

264. (currently amended) The method according to claim 258 where the at least one adsorber includes a layer of guard material and the method further ~~comprising~~ comprises reducing contaminant loading of the guard material during startup.